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Technology levels for maritime traffic coordination

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Technology levels for maritime traffic coordination: towards the internet of intelligent ships

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Coordinated marine traffic is necessary for avoiding collisions and groundings as ships have to stay clear from each other in restricted sea-areas. Both on-board activities, of which active lookout is primary, and external means, such as seamarks, are necessary. There has been and will be substantial technological change in achieving this coordination.

The objective of this study is to differentiate technology levels in marine traffic coordination. We will also consider the safety implications of ships of mixed technology levels: already now, marine traffic consists of vessels that operate both with and without certain safety tools, such as, AIS and radar, these usually being absent from smaller leisure boats. This diversity of tools is likely to increase as more and more advanced systems will be taken into use. Furthermore, we will also consider the possible transition to the use autonomous vessels, the argument being that this transition will be easier to achieve is there will generic increase in the automated connectivity and coordination between all kinds of vessels.

As for the method used, existing studies and understanding of technological progress was synthesised and assembled into logically differentiated levels. In doing so, existing models of technology levels, such as those for self-driving cars were considered for inspiration. We also see that the forthcoming poster presentation session on the levels now created will serve as method for gaining feedback and insight from the professionals of the field; a refined model will be created based on the feedback gathered. The results include a five-level model described and discussed level-by-level below. Table 1 synthesises and exemplifies the levels as well.

Level 0 “I can see you” considers marine traffic coordination without communication, localization or identification tools. Coordination is based on lookout and shouting only. It is unclear to us, which came first, rudimentary seamarks, such as lighthouses, or professional piloting service. Nonetheless, it can be imagined that certain kind of use of local expert has been used for long in approaching unknown harbour waters. For this reason, and because the use of technology is not necessary, piloting service is located on level 0 as a means for coordination based on external actor or aid.

Level 1 “I can see your flags” includes shared rules, such as today’s COLREGs, as well as shared signalling tools, such as flags and lights on ships. Seamarks, such as lighthouses and cairns (i.e., human-made piles of stones) for safer navigation belong to this level as well.

Level 2 “My radar sees you” includes tools that utilise signal transmission. In other words, satellite positioning, radar and radio-communication belong to this level, all of which help in navigation and collision avoidance.

Level 3 “I can see data about you” includes sharing digitally stored data. Differentiating between Level 2 and Level 3 requires some consideration: we propose here that GPS systems that use digital decoding belong to Level 2, i.e., digital storage makes the difference.

Level 4 “My robot sees you” includes systems that are usually considered the backbone of autonomous ships: machine learning (AI) based object detection and computer-game-like autonomous navigational decision making. AI is used for fleet route optimization as well.

Level 5 “My robot sees what your robot sees” includes that the intelligent ships of Level 4 are interconnected and share data. At Level 5, the maritime traffic adjusts itself as a self-organized system. This is in contrast to Level 4 on which the human operators monitoring ships and/or fleets have to discuss with other Level 4 ships/fleet operators in sharing navigational plans.

Level 5’s internet of intelligent ships facilitates the introduction of autonomous ships on a global level; on Level 4, autonomous ships could arguably operate only on relatively fixed routes. With shared data from all traffic conditions and various harbours, AI is better able to predict safe routes in these varying conditions. Level 5 is also seen to include a more robust business case for autonomous ships, since it requires less human intervention and monitoring. In the near future, however, it is highly unlikely that all ships, including small leisure boats, would take part in Level 5 internet of ships with a shared system of location signalling and traffic coordination. Instead, a number of mixed operation scenarios involving different coordination levels are expected to co-exist simultaneously. New risks might arise from this mixed setting of tools and devices. The ships with different levels may need to use a multitude of parallel communication and coordination methods, potentially hindering the capability for unambiguous communication and creation of adequate situational awareness. Future studies should explore the implications of interactions between the different coordination levels, focusing especially on the technologies that enable autonomous shipping. Differentiating technology levels helps to provide common vocabulary for the future studies proposed.

Marine traffic coordination technology level	**Model of marine traffic coordination**	
	Coordination based on interaction between ships	*Coordination based on external actor or aid*
Level 0 – “I can see you”: non-technological coordination only	visual assessment of trajectories, shared natural language	piloting service
Level 1 – “I can see your flags”: shared rules and passive communication mediums	flags, lights and other ship-based communication signs, COLREGs	sea-routes, light-houses, etc. visual navigational aids
Level 2 – “My radar sees you”: signal-based detection, localisation and communication systems	Radar, VHS-radio communication, transponders	satellite connections
Level 3 – “I can see data about you”: digitally enhanced coordination (sharing digitally stored data)	AIS, waypoint/route-sharing, data-sharing through VHS-radio / transponders	VTS service, commercial fleet management systems
Level 4 – “My robot sees you”: smart coordination (localized/fleet/ship-level coordination based on machine learning and other predictive technologies)	on-board object detection systems, autonomous navigational decision-making	fleet route optimization, fleet management of intelligent/autonomous ships
Level 5 – “My robot sees what your robot sees”: internet of intelligent ships (global coordination based on machine learning, using shared data)	AI-optimized route generation and situational awareness based on global network of intelligent ships	AI-based coordination guiding the internet of intelligent ships, with data collected by land-based agents (e.g., harbours and seamarks)

Table 1. Technology levels for marine traffic coordination